

20. Observations on the Habits of *Cochlitoma zebra*, var. *fulgurata* (Pfeiffer), and *Cochlitoma zebra*, var. *obesa* (Pfeiffer), in Confinement *. By JANE LONGSTAFF, F.L.S., F.G.S.

(Communicated by Lient.-Colonel RALPH LONGSTAFF, D.S.O., F.Z.S.)

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(Plates I.-III. †)

When visiting Cape Colony, during 1914, I obtained six specimens of *Cochlitoma zebra*, var. *obesa*, at Humewood, Port Elizabeth, on March 31st. From these I selected two examples, which I brought home alive in company with a fine specimen of the var. *fulgurata* (the latter was presented to me by Mr. O'Connor, of the "Woods and Forests," who found it at Keiskamma Hoek, about nineteen miles north-west of King William's Town).

On leaving Cape Town, on April 11th, I put all three together in a tin box, which I opened frequently during the voyage, so as to feed them and allow them to crawl about. Upon arrival, on April 28th, I placed them in the conservatory.

In bringing these molluscs to England I had no intention of breeding them, but only surmised they might be of interest for anatomical purposes—therefore I did not keep the two varieties separate; and subsequently there was great mortality among the young through lack of preparation and inexperience.

Broods of original Specimens.

April 29th, 1914.—The smaller example of var. *obesa* had deposited during the night sixteen young molluscs and about thirty eggs; seventeen of the latter were either broken or punctured.

The two varieties were now placed in different pots, with sandy soil, tufts of grass, and varied food-leaves; also the parents were separated from the eggs and young in every case.

May 4th.—The larger specimen of the same variety deposited a dozen or more living young ones and numerous eggs. No fragments of egg-shells were then observed, but the next day I noticed that two of the young were much smaller than the others, and that one of them had a small bit of egg-shell adhering to it—also that there were some pieces of egg-shell lying near them. None of these fragments looked large enough to have contained the biggest of the young, but they might have

* I have followed Major Connolly ('Annals of the South African Museum,' vol. xi. pt. iii. 1912, pp. 204, 205) in regarding these forms as varieties of *Cochlitoma zebra* (Chemnitz).

† For explanation of the Plates, see p. 387.

held the smaller ones. Thus the two latter had evidently hatched from the eggs after they were laid. I did not ascertain the exact numbers at first, as I was afraid of disturbing them, but I now counted seventeen young molluscs and about fifty eggs, many of which were cracked.

May 4th.—I discovered that var. *fulgurata* had deposited two living young ones, which were buried in the soil, without any eggs or fragments of egg-shell associated with them. These died that day when on a visit to the British Museum (Nat. Hist.), where a drawing of one was made.

May 7th.—Var. *fulgurata* laid about seventy eggs near the surface, without any living young molluscs.

May 15th, 16th, 17th, 21st, 22nd, and 25th.—On each of these days an egg hatched, thus there were six young var. *fulgurata* from the eggs laid on the 7th. Some of the other eggs cracked, but with one exception no more molluscs came out.

June 1st.—This one hatched, but the animal died immediately and the shell was cleared out, either by *Agriolimax agrestis* Linn. (which had been introduced, probably on lettuce) or else by its brethren.

September 9th, 11th, and 12th, 1915.—The larger specimen of var. *obesa* was observed to have deposited another brood. On each of these days a single young mollusc appeared on the surface. I then scraped up the soil gently, to the depth of one or one and a half inches, and discovered nine additional young ones. Ten were about the same size, while two were smaller—there were no eggs or fragments of egg-shell.

October 8th.—Two additional young ones were observed with the parent. It is not evident whether these were overlooked before (for young shells, when covered with soil, greatly resemble pebbles), or whether they had been deposited more recently. One was of about the same dimensions as that of the medium size, and the other was about equal to, or rather less than, the smallest of the previous ones.

October 31st, 1916.—This brood was entirely killed by a single specimen of *Arion hortensis*, which I found beside them. Thus they existed little more than a year.

Hibernation and Mortality.

May 7th–July 13th, 1914.—The var. *fulgurata*, after laying eggs, formed an epiphragm and between these dates buried itself. Then it came up at night and ate lettuce, but went below during the day, and continued doing this for about a fortnight, when it remained completely buried till the beginning of October. At this time it rose, and died on November 26th, after having been in confinement eight months.

Winter, 1914–15.—The four young var. *fulgurata*, which alone were living, commenced to hibernate in October and remained below till March 4th. One, however, had protruded its head

and eaten lettuce on February 8th, and then retired again. Only two survived the winter.

November 25th.—The two adult var. *obesa*, as well as the young ones, commenced to hibernate, and they remained more or less, but not continuously, inactive till February 8th, 1915.

May 24th, 1915.—The smaller adult var. *obesa* buried itself, and as it did not rise again I dug it up on July 12th, when I found it was dead, after being from fourteen to sixteen months in confinement.

Winter, 1915-16: October 9th.—The two young var. *fulgurata* hibernated. One came up January 6th, the other on the 29th.

November.—During this month the single adult and the young var. *obesa* buried themselves till January. The former rose on the 20th and remained on the surface till March 2nd, when it died, after about two years in confinement.

Winter, 1916-17.—Two young var. *fulgurata* began hibernating in September, but roused up and ate at the end of February; the weather, however, becoming very cold caused them to go below again till late in March. One died in June, when about three years old.

November.—There were now only six young var. *obesa* living, these began to hibernate during this month. They did not, however, remain continuously below, but came up at different times, though they did not eat. Three died in February and two in March, thus only one specimen remained which belonged to the first brood.

Winter, 1917-18.—The solitary specimen of var. *fulgurata* began hibernating at the end of September and roused up at the end of January. The single example of var. *obesa* was only dormant from December 15th to January 24th.

Winter, 1918-19.—Var. *fulgurata* hibernated from the first week in September till February 22nd. Var. *obesa* from the first week in October till February 21st.

Winter, 1919-20.—Var. *fulgurata* hibernated from September 29th till February, when it came up, but retired again below till the middle of March. Var. *obesa* was buried from October 6th till the middle of March.

The hibernation of the original var. *fulgurata* during our summer may be explained by the fact of that season being dry and cooler in the district whence it came, when it would naturally rest. There being no marked difference between the dry and wet seasons at Port Elizabeth would cause var. *obesa* to be more adaptable. It must be remarked, however, that the young var. *fulgurata* did not follow the example of their parent, but that of var. *obesa*.

The conservatory in which the molluscs lived was heated, and did not fall below 45° F. at night in winter. Nevertheless, they seemed to feel variations in temperature, for there was greater mortality in cold weather, and if they roused up earlier from hibernation during a mild spell they generally went down again

when there was a return of cold. During hibernation they invariably closed the aperture with an epiphragm, which had a slit at the posterior end (Pl. I. fig. 13).

Broods of Progeny.

June 21st, 1918.—As there was only one specimen of each variety living I placed them both together, but they did not appear to like one another at first, for they went as far apart as possible. Later on, however, they became more friendly.

September 16th, 1919.—Several young ones and also some eggs were discovered below the surface, and the adults were separated from them. On the 19th I counted eleven young molluscs, twelve eggs, and three broken bits of egg-shell. On the 26th I found another and still smaller young one, with two bits of egg-shell. It had, therefore, hatched from an egg, but there is no evidence to show whether the whole of those first found had done so. Var. *fulgurata* appeared to have deposited this brood.

July 23rd, 1920.—I scraped up the soil to a depth of about two inches, and discovered fifteen living young molluscs and two dead ones, accompanied by some fragments of egg-shell. The two dead shells were very small, had no coloured markings, and were without any trace of the animals.

August 4th, 6th, and 12th.—Other living ones were found, making nineteen in all, and the eggs numbered between fifty and sixty. It is not clear which variety deposited the young ones. After finding these I actually saw var. *obesa* lay some of the smaller eggs; it is, however, quite possible that var. *fulgurata* may have laid some of the larger ones.

Hibernation.

Winter, 1919–20.—October 6th to the middle of March.

Winter, 1920–21.—Both broods commenced to hibernate the middle of October. During mild spells in January they came up and ate. There were nine living of the first brood and seventeen of the second, all grandchildren of the original specimens.

Summer, 1920.—Var. *fulgurata* was not so active as usual, appeared sickly in August, and finally died on September 22nd at the age of six years and four months.

October 24th.—Var. *obesa* died after being inert several days, when six and a half years old.

Reproduction.

Unfortunately, the cases here described do not afford clear evidence of the length of time elapsing between fertilization and birth. The two original specimens of var. *obesa* travelled together with one of var. *fulgurata* for seventeen days. The former may have fertilized each other, or they may have been fertilized previously by their fellows, or, on the other hand, they may have been impregnated by var. *fulgurata* on the journey. With regard

to the var. *fulgurata*, five or six weeks had elapsed since it had the opportunity of copulation with its own kind, but there is the possibility of its having been crossed with var. *obesa*; fertilization in transit was unlikely as the specimens were tightly packed.

The second brood (September 1915) of the larger specimen of var. *obesa* must have been produced either from the prolonged effect of the previous copulation, or else the mollusc must have been fertilized afresh at least four months before, as that length of time had elapsed since separation from its only fellow. As far as can be judged from the appearance of the animals and shells, cross-breeding does not seem to have taken place. It is, however, a question whether the two broods of the progeny of the original specimens may not be the result of cross-fertilization. The brood of var. *fulgurata* (September 1919) was deposited about two years and three months after the death of the last individual of its own kind, aged three years, and after it had been living with var. *obesa* about fifteen months. The actual parent of the young ones deposited July 1920 is doubtful. If it was var. *obesa*, and fertilized by its own form, three years and four months had elapsed since the death of its last companion, which was then barely three years old. If fertilization was by var. *fulgurata* it may have taken place any time after June 1918. If var. *fulgurata* was the parent, either the effect of the first copulation must have continued or else there must have been crossing with var. *obesa*. The latter variety certainly laid some of the eggs, but it is not evident whether any hatched.

These last two broods are as yet too young to ascertain whether there are signs of cross-breeding. The older one, however, bears most resemblance externally to var. *fulgurata*. In connection with this I would point out that Mr. Darbshire*, in an abstract of Prof. Lang's experiments with *Helix hortensis* and *Helix nemoralis*, quotes an example of one of the snails being fertilized in 1900, which, without further copulation, produced four families in the years 1900, 1901, 1902, and 1903. Dr. Cooke† gives instances of the prolonged effect of a single copulation in *Helix aspersa* and *Arion ater*. In the case of the former the first batch of eggs was laid after the lapse of only four days, and the second the following summer. In the latter a month elapsed, and then this pair of *Arion ater* both laid batches of eggs at intervals during a period of seven weeks. He also quotes from a paper communicated by Mr. J. S. Gaskoin to the Zoological Society in November 1850, to the effect that *Helix lactea* produced young after being isolated four and a half years.

Eggs and Young.

It is of interest to note that these two varieties of *Cochlitoma* have been observed to be at the same time both ovoviviparous

* Jour. Conch. vol. xi. no. 7, 1905, p. 194.

† "Molluscs," Cambridge Nat. Hist. 1895, p. 42.

and oviparous, and also that var. *obesa* had one brood entirely ovoviviparous. A dead specimen of the latter variety, found associated with the living ones, contained a number of dead young shells, with which no eggs were noticed.

Dr. Pilsbry* states that *Cochlitoma* is ovoviviparous, and gives an instance of Semper having found in the uterus of a specimen of *C. zebra* sixty undeveloped eggs with calcareous shells, the largest measuring 6 mm. in length and the smallest 3 mm., together with twenty-five embryos which had crawled out of the egg-shell. Further†, he remarks that Mr. Clapp found young shells of about 8 mm. in diameter inside a specimen of *C. crawfordi* (Morelet), with which there were no traces of calcareous egg-shell.

The dimensions of the eggs of the different broods vary: var. *fulgurata* has the largest eggs—these are preserved in such a manner as to show the structure best. The eggs are calcareous, yellowish in colour, and short-oval or rounded in form. The biggest measure 9 mm. in length by 7.5 mm. in width; the smallest 3.75 mm. in length by 3.25 mm. in width. Inside the outer calcareous shell there is an amber-coloured layer which does not cover the whole of the interior, and which appears to give rise to the embryonic molluscan test. Fully a dozen of the broken eggs of var. *fulgurata* contain the embryo and exhibit a very thin grey layer, more or less calcareous, covering the aperture and the greater part, if not the whole, of the shell. The young shell consists of little more than three whorls, of which the earliest is smooth, pale horn-colour, with the apex slightly sunk; the succeeding whorls have spiral lines crossing the lines of growth and rendering the surface granulated; the brown-coloured markings begin on the last third of the body-whorl, before it leaves the egg, and they form an interrupted spiral band with a few longitudinal brown lines near the aperture. The soft parts of the animal have entirely disappeared from all the eggs. A young shell, released from a broken egg, had a length of 7.5 mm. and width of 8 mm.

The later brood of var. *fulgurata* (offspring of the original specimen) contained fewer eggs but more living young molluscs. I broke one of the twelve eggs, and found it was not so far advanced as some of those of the first brood, as there was only the amber-like layer inside the calcareous shell. The largest measures 8.25 mm. in length by 6.5 mm. in width; the smallest 6.5 mm. in length by 5.5 mm. in width.

One of the biggest eggs of the larger example of var. *obesa* measured 8 mm. in length and 6 mm. in width; one of the smallest, 3 mm. in length and 2.5 mm. in width. The biggest egg of the smaller parent is less, measuring 5.5 mm. in length by 4 mm. in width.

The latest brood, which is probably mixed, contains eggs

* Man. Conch. vol. xvii. ser. 2, p. 77.

† *Ibid.* p. 93.

varying from 7 mm. to 3.75 mm. in length, and from 5.5 mm. to 2.75 mm. in width.

Growth.

The young molluscs of the different broods varied in size and rate of growth; specimens of each of the earlier broods have been figured at intervals to show the latter (Pls. I. & II.). As far as possible the same individual was represented, but when one died another of the same brood was substituted. The rate of growth was not always uniform, and sometimes a smaller specimen surpassed a larger companion. The difference in size was shown in a remarkable manner in the case of the latest brood of var. *fulgurata* (September 1919), which consists of the grandchildren of the specimen originally brought home. Three days after discovery the largest measured 20 mm. in length and 15.5 mm. in width, while a week later the smallest, which was probably hatched from an egg, had a length of 10 mm. and width of 9 mm. On May 4th, 1920, about six weeks after they ceased hibernating the smallest was the same size as before, while the largest had a length of 22 mm. and width of 16.5 mm. There was also another remarkably small one. These two small examples were not long-lived, for the first-mentioned died on May 27th, when it measured 10 mm. in length and 9.5 mm. in width. The second died in October, when it was 13 mm. in length by 10.5 mm. in width. A living companion of average size at this time measured 42 mm. in length and 29 mm. in width. This last, and the rest of the brood, were then commencing to hibernate, so I did not wish to disturb them to make further measurements.

The drawings represent the first broods up to the age of three years and four months, when (September 1917) only one specimen of each form was living. Neither of these had been figured before, and they were then figured with the animals (Pl. III. figs. 1 & 2). At that date this specimen of var. *fulgurata* measured 71 mm. in length and 41 mm. in width; var. *obesa* 57 mm. in length and 39 mm. in width.

In September 1918 var. *fulgurata* measured 81 mm. in length and 46 mm. in width; var. *obesa* 77 mm. in length and 49 mm. in width.

In September 1919 var. *fulgurata* measured 88 mm. in length and 49 mm. in width; var. *obesa* 80 mm. in length and 52 mm. in width. At death var. *fulgurata* had attained a length of 89 mm. and width of 50 mm.; var. *obesa* a length of 80 mm. and width of 52 mm. It must be noted that both grew most between September 1917 and September 1918, and least during the last year of their lives. The increase in all cases was actually made after hibernation, between the months of January and September of each year. Var. *fulgurata* did not attain the length of its parent, which was 107 mm.; but var. *obesa* exceeded the size of its parent (smaller specimen), which only measured 68 mm. in length and 47 mm. in width.

Resemblances and Differences.

In extreme youth the shells of the two varieties greatly resemble one another, but the brown markings, so far as I have observed, appear to commence earlier in var. *fulgurata* than in var. *obesa*. The embryos of the latter form, found inside a dead specimen, do not show them at all, and I have only noticed the faintest trace of them in one embryo. As the molluscs grow older, however, they differ in character and colour of the shell, as well as in the colour of the animal. The specimens of var. *obesa* examined vary somewhat in the spiral angle of the shell, but on the whole it is wider than that of var. *fulgurata*. The shell of var. *obesa* is lighter in colour, being white or yellowish white, while that of var. *fulgurata* is deep horn-colour; both are ornamented by brown, longitudinal, more or less zigzag streaks, which are less closely packed on var. *fulgurata*, and are also broader on the body-whorl. The appearance of the latter is like horn or tortoise-shell, while var. *obesa* is more porcellaneous, and is thus similar to the typical *C. zebra*.

The colouring of the animal of var. *fulgurata* is pale greenish or yellowish grey, reticulated with a darker shade, and there are three almost black stripes running down the head, with a banana-yellow stripe on each side of the central one. In var. *obesa* the animal is lead-grey reticulated with a darker shade; it also has three dark stripes, which are not so nearly black as those of var. *fulgurata*, the central stripe is broader, and those on each side are light grey. The fringe and sole are darkest in var. *obesa*.

The eggs of var. *obesa* are proportionately longer than those of var. *fulgurata*, but on the whole they are smaller.

The habits of the two varieties also differ somewhat. Var. *fulgurata* is more nocturnal, moving about and eating most at night, while var. *obesa* moves about during the day as much as at night, and lives more continuously near the surface. The former is more vigorous in its movements, making rapid and deep excavations. It has also been noted that the progeny of the original var. *fulgurata* generally hibernated earlier, seeming to require a longer period of rest. Contrary to its usual custom, the solitary example of this variety lived on the surface during the last summer of its existence, and did not appear to have the energy to move much or to burrow.

Food.

The favourite food of both forms is lettuce, and next to that dandelion and the leaves of the Life Plant (*Bryophyllum calycinum* Solisb.). They ate the skins of grapes that had been sucked, but could not manage the entire fruit; also banana and the outer leaves of cauliflower, when there was nothing else. They positively disliked cabbage and sprouts, either fresh or cooked. All had a habit of dragging leaves into their burrows, and some-

times the mollusc would remain buried while merely the head was protruded for feeding.

I am greatly indebted to Mr. G. C. Robson for several valuable suggestions, also for affording me every facility when studying specimens under his care.

EXPLANATION OF THE PLATES.

PLATE I.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Drawn June 17th, 1914. $\times 2$. Born April 29th, 1914.
 2. Brood II. Drawn shortly after birth, May 4th, 1914. $\times 2$. (Shell lost.)
 2a. Brood II. Sculpture, greatly enlarged.
 3. Brood II. Different specimen, drawn June 17th, 1914. $\times 2$.
 4, 4a. Brood II. Eggs of medium and small size. $\times 2$. Larger one showing inner amber-like layer.

Cochlitoma zebra, var. *fulgurata* (Pfeiffer).

5. Drawn May 4th, 1914, soon after birth. $\times 2$. (Died after visit to the Museum.)
 5a. Sculpture greatly enlarged.
 6. Drawn June 17th, 1914. $\times 2$. Hatched from an egg, May 15th or 17th, 1914.
 7. Egg, laid May 7th, 1914, showing inner amber-like layer. $\times 2$.
 8. Embryo, with egg-shell partly broken away, and showing inner thin calcareous layer, also the brown markings on the last whorl. $\times 2$.
 9. Specimen previously figured June 17th (fig. 6), drawn again July 28th, 1914. $\times 2$.
 10. The same, drawn September 15th, 1914. $\times 2$. (Died immediately afterwards.)
 11. Another shell, drawn April 9th, 1915. $\times 2$.
 12. The same, drawn June 30th, 1916. Nat. size. (Died June 1917.)
 13. Portion of epiphragm, showing slit. $\times 2$.

PLATE II.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Same as Pl. I. fig. 1, drawn July 28th, 1914. $\times 2$.
 2. " " " " " " September 15th, 1914. $\times 2$.
 3. " " " " " " April 9th, 1915. $\times 2$.
 4. " " " " " " June 30th, 1916. Nat. size. (Died September 1916.)
 5. Brood II. Same as Pl. I. fig. 3, drawn July 28th, 1914. $\times 2$.
 6. " " " " " " September 15th, 1914. $\times 2$.
 7. " " " " " " April 9th, 1915. $\times 2$.
 8. " " " " " " June 30th, 1916. Nat. size. (Died February 1917.)

PLATE III.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Drawn September 5th, 1917. Nat. size. (Not figured previously.) Born April 29th, 1914. Died September 1920. Dissected by Mr. G. C. Robson.

Cochlitoma zebra, var. *fulgurata* (Pfeiffer).

2. Drawn September 5th, 1917. Nat. size. (Not figured previously.) Hatched from an egg, between May 15th and 25th, 1914. Died September 1920. Dissected by Mr. G. C. Robson.

All the specimens figured have been given to the British Museum (Nat. Hist.).